MONITORING PLAN

PROJECT NO. MR-09 DELTA WIDE CREVASSES

April 22, 1999

Project Description

The project area is located in Plaquemines Parish to the southeast of Venice, Louisiana on the active Mississippi River Delta (figure 1). This project utilizes the major process that forms subaerial land in the lower Mississippi River Delta, the formation of crevasses. Crevasses are breaks in the levee that allow overbank deposition of sediments to occur in adjacent interdistributary receiving bays. This deposition of sediments causes land formation that is controlled by the processes of distributary mouth-bar islands. Coleman and Gagliano (1964) ordered the mouth-bar island process into crevasse sub-delta and crevasse-splay based on relative size. Crevasse sub-deltas consist of relatively large receiving bays that have areal extents of 115-154 sq mi. (300-400 sq km) and depths of 32-49 ft (10-15 m). The process by which these sub-deltas are formed is referred to as "bay filling" (Coleman and Gagliano 1964). Crevasse-splays are a smaller sub-unit that are distinguished from sub-deltas in that their size, frequency, and expected life spans are smaller generally having a receiving bay extent of approximately 0.234 sq mi. (0.59 sq km) (Boyer 1996).

The project consists of maintaining presently existing crevasse-splays, the construction of new crevasse-splays, and future maintenance of selected crevasse-splays in both the Pass-A-Loutre Wildlife Management Area (PALWMA) and the Delta National Wildlife Refuge (DNWR). The PALWMA covers 66,000 ac (26,709 ha) between Pass-A-Loutre and South Pass and is owned and managed by the Louisiana Department of Wildlife and Fisheries (LDWF). The DNWR covers 48,000 ac (19,425 ha) from just north of Main Pass southward to Pass-A-Loutre and is owned and managed by the U.S. Fish and Wildlife Service (USFWS). It is understood that the natural cycle of crevasse-splays is a temporary event that is rarely active for more than 10 to 15 years. This process of crevasse-splay deposition, building, and subsidence will all be considered in the evaluation of this project.

River deltas are extremely variable and dynamic environments. This was noted quite early in the geologic literature, as was commented upon by Lyell (1847) and Riddell (1846). Both authors noted that changes in the sites of sedimentation at the mouths of the Mississippi River were quite rapid. However, they lacked the information as to what was driving these processes. This wasn't fully realized until the groundbreaking work of Russell, Fisk, and their contemporaries in the 1930's, 1940's, and 1950's (Trowbridge 1930, 1954; Russell 1936, 1940, 1958; Russell and Russell 1939; Fisk 1944, 1947, 1952, 1955, 1966, 1961; Fisk et al. 1954; Fisk and McFarlan 1955; Bates 1953; Shepard 1955,1956; Scruton 1960; Kolb and Van Lopik 1966; Welder 1959). Their research not only formed the basis of core knowledge of delta processes on the Mississippi, but on river systems worldwide.

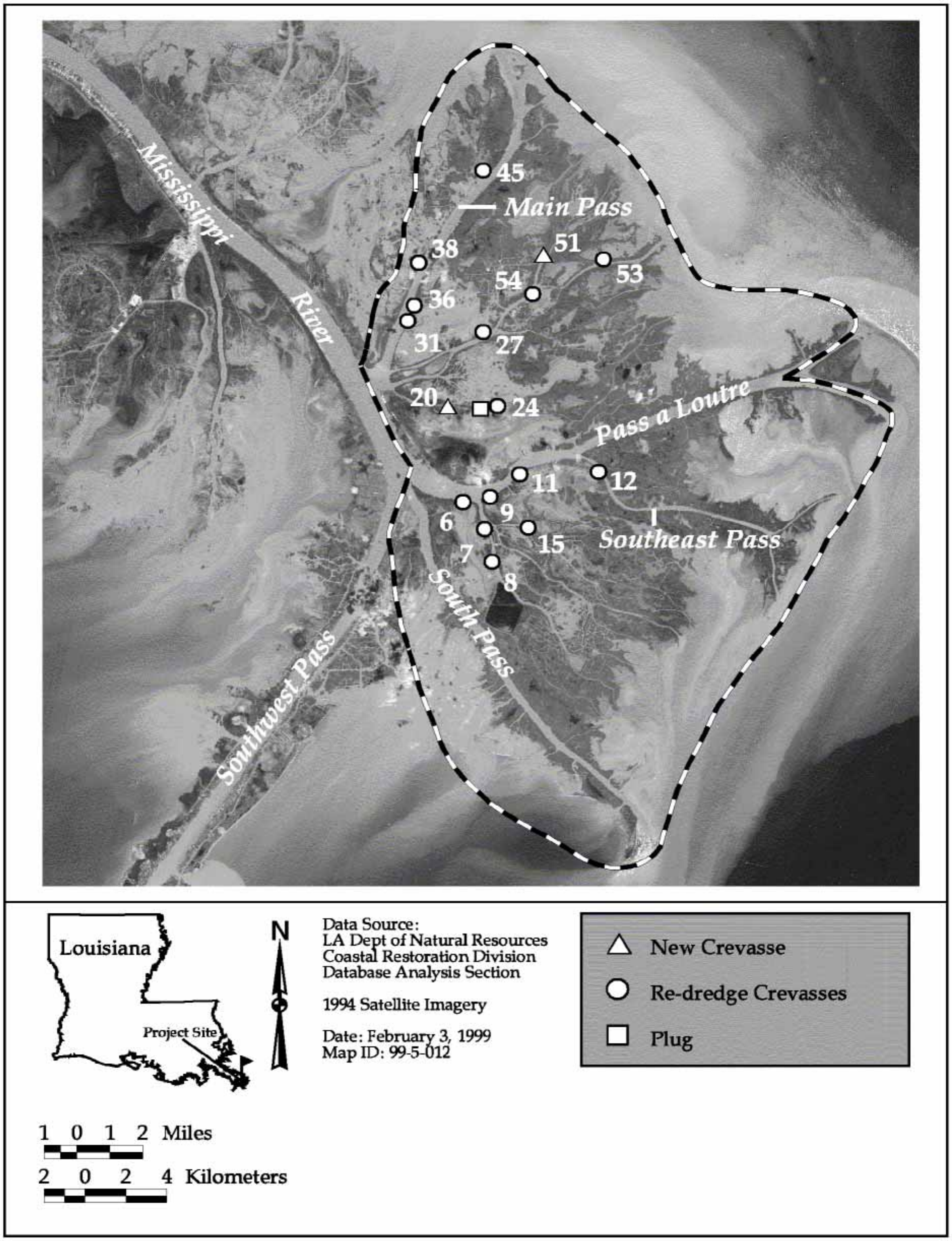

Figure 1. Delta Wide Crevasses (MR-09) project location.

Land in the entire Mississippi River deltaic plain was formed during the last 6,000 years by sediment deposited into major deltaic lobes (sub-deltas). The lobes together have built a plain that spans approximately 11,030 mi^2 (28,568 km^2) of which 9,228 mi^2 (23,900 km^2) is subaerial in nature. The current Mississippi River Delta (also referred to as the Balize Delta, Modern Delta, Plaquemines Delta, and Birdfoot Delta) is the fifth in a sequence of six major lobe complexes (Coleman 1988). Its formation initiated approximately 1,000 years ago through channel switching and bifurcation processes. During this period of active delta growth (also known as the progradation phase of the transgressive deltaic cycle), distributaries actively prograde seaward, and overbanking during floods fills the shallow interdistributary bays (figure 2). This allows sediments to accumulate faster than subsidence or sea level rise can bury them. When a new site of deposition is formed, the distributary channels, now cut off from their supply of sediment, cease to prograde, and wave processes rework the distributary mouth bar sands, allowing initial transgressive processes to begin. The natural trend for the Mississippi River at this point in time would be to enter the abandonment phase of the transgressive deltaic cycle.

The processes of wetlands creation on the Mississippi Delta have been disrupted through both natural and man-made processes. The major anthropogenic factors that are to blame are the construction of a series artificial levees for flood control and navigation canals for ship traffic. Levee construction is deleterious to wetland creation in that it diverts necessary sediment flow onto the continental shelf and causes seaward progradation of the river mouth at rates up to 100 m/yr within the past several decades. Levees also prevent the seasonal flooding of marsh habitat. This rapid deposition, together with gas formation (methane formed through the bacterial breakdown of organics in the sediments) and wave loading has created an unstable delta front (Coleman et al. 1974; Prior and Coleman 1978a, 1978b; Roberts et al. 1980). Instabilities associated with this have been responsible for the removal of large volumes of sediment from the delta front onto the continental slope or basin floor through rotational and retrogressive slides. This in consort with saltwater intrusion caused by canals has caused a tremendous deterioration of wetlands along coastal Louisiana.

Rapid wetland deterioration in the Mississippi River Delta is likely due to a combination of the above anthropogenic factors, as well as natural processes such as subsidence and eustatic sea level rise. The subsidence rate for the entire delta is approximately 0.45 in/yr (1.1 cm/yr) (Day and Templet 1989) as evidenced by the several hundred hectares of shallow water ponds that have replaced former freshwater marshes (White 1993). Subsidence rates are further exacerbated by frequent canal dredging for navigation purposes and by fluid and gas withdrawals for mineral resources mining. The most recent land loss rate estimate for the Mississippi River Delta is 5.37 mi^2/yr (13.91 km^2/yr), which is 21% of the total annual land loss occurring in the Louisiana coastal zone (Dunbar et al. 1992).

It is important, therefore, to mimic the natural crevasse formation process that was once so vital in delivering sediment and freshwater flow to the Mississippi River Delta. The sediment carried in the water from a newly created crevasse quickly settles out of the water column and allows subaerial land to be created. This is the foundation for future colonization by marsh vegetation and wildlife habitat. Future growth of the newly created marsh occurs through sediment trapping action of the

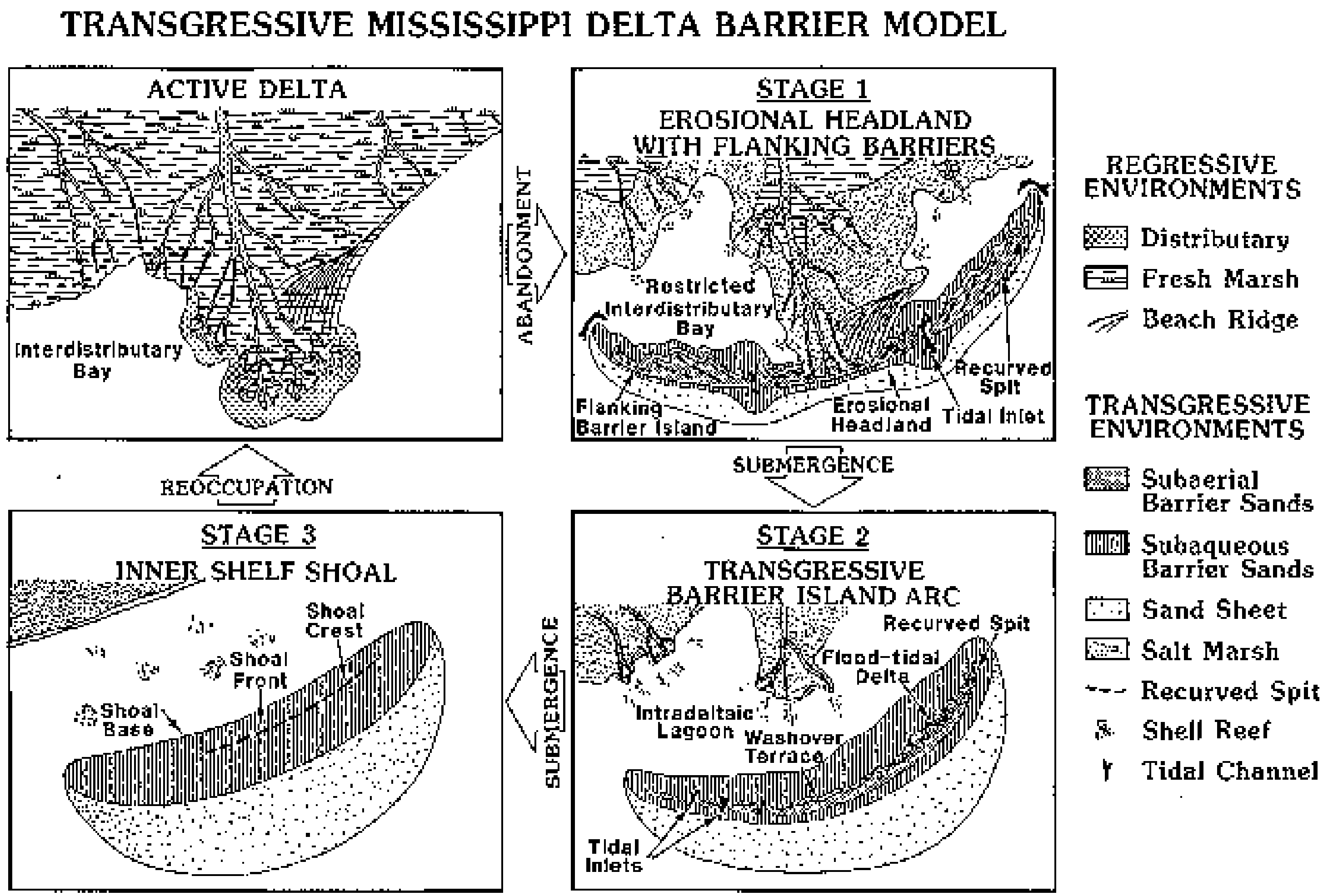

Figure 2. Stages in a deltaic cycle (Penland and Boyd 1981).

emergent vegetation. This process forms the major subaerial land found in the lower Mississippi River Delta. Overbanking does not occur each year, but is normally associated with high flood events.

The usefulness of crevasses as a tool of wetland and coastal management on the Mississippi River Delta began to be realized in the early 1980's. The Louisiana Department of Natural Resources (LDNR) constructed three new crevasses in 1986 (on Pass-A-Loutre, South Pass, and Loomis Pass) that produced over 657 ac (266 ha) of emergent marsh from 1986 to 1991, and four crevasses in 1990 (two each on South Pass and Pass-A-Loutre) that produced over 400 ac (162 ha) of emergent marsh from 1990 to 1993 (LDNR 1993; Trepagnier 1994). Thirteen crevasses included in the LDNR Small Sediment Diversions Project cumulatively produced 313 ac (127 ha) of emergent marsh between 1986 and 1993; land growth rates ranged from 28 to 103 ac (11.3 to 41.7 ha) per crevasse for the older crevasses (4 to 10 years old) and 0.5 to 12 ac (0.2 to 4.9 ha) for the younger crevasses (0 to 2 years old) (LDNR 1996). Boyer et al. (1997) concluded that crevasses in the DNWR accumulated land at about 11.6 ac/yr (4.7 ha/yr), but subaerial growth did not occur for 2-3 years after the crevasses were cut.

The colonization of an emergent mudflat as produced by a crevasse has been well documented (Neill and Deegan 1986). The general pattern of habitat change on the deltaic plain is as follows: fresh marshes colonize newly created mudflats of low salinity. Fresh marsh, intermediate marsh, and swamp increase as the delta grows, and brackish marsh occurs away from the river mouth. As a lobe is abandoned and salinity increases, brackish and salt marshes increase near the coast at the expense of less saline marshes, which concurrently retreat inland. White (1993) delineated the vegetative ecological succession that occurs on newly emergent delta into three major plant communities: (1) forests of *Salix nigra* (black willow) establishing on upstream, high elevation islands that usually consist of the coarsest sediments, (2) stands of *Scirpus deltarum* (delta three square) that develop downstream from the forested islands at intermediate elevations (between 4 inches [10 cm] and sea level), and (3) communities of *Colocasia esculenta* (elephant ear) developing just downstream from the forested islands, where the finest sediments are deposited and land elevation is below Mean Sea Level (MSL).

The soils in this area are predominantly Balize and Larose types. These soils may be classified as continuously flooded deep, very poorly drained and very permeable mineral clays and mucky clays. They are distributed on the fringes of freshwater marshes, adjacent to the natural distributary levees of the Mississippi River, at an elevation less than 3 ft (0.9 m) and a slope of less than one percent. Since Larose soils are deposited underwater, never being air-dried or consolidated, they remain semifluid and highly unstable (Natural Resources Conservation Service, unpublished data).

The 20-yr project is to be implemented in a series of mobilizations every five years. At the close of each mobilization cycle the project will be re-evaluated to determine the success of existing crevasses, if maintenance is required, and the possible addition of new crevasses to the project area. The first phase of mobilization features for this project include:

1. Create two new crevasse-splays in the Delta National Wildlife Refuge. To this end, crevasses will be constructed to the dimensions of approximately 100 feet wide by six feet deep.

2. Maintain approximately 15 existing crevasse-splays located in the DNWR (8) and in the PALWMA (7). The existing crevasses will be redredged according to their needs, either by increasing their width, depth, or angle of opening.

3. A plug will be constructed in an existing crevasse north of Raphael Pass to increase flow to the crevasse-splay downstream.

Project Objective

1. Promote the formation of emergent freshwater and intermediate marsh in shallow open water areas through the construction of new and maintenance of new and existing crevasse-splays.

Specific Goals

The following measurable goals were established to evaluate project effectiveness:

1. Maintain or increase land to open water ratio within the receiving bays.

2. Increase mean elevation of the receiving bays.

3. Increase the mean percent cover of emergent fresh and intermediate marsh type vegetation in the receiving bays.

Reference Area

A formal reference area was not selected for this project, following the justification set forth in Steyer et al. (1995). It has become common practice within the last 10 years for the two refuge landowner agencies (USFWS and LDWF) to construct crevasses throughout the delta. Presently, DNWR has approximately 25 constructed crevasses and PALWMA has approximately 20 constructed crevasses. Both agencies have communicated a strong potential for additional crevasses to be constructed in the near future. The extent of future wetland alterations in the delta is therefore unknown and could likely result in the loss of a reference area before monitoring for MR-09 is completed. As an informal reference, aerial photography taken throughout the entire Mississippi River Delta will be utilized to evaluate temporal changes in open water areas that have not been influenced by crevasse splays. Additionally, results from other sediment diversion projects (e.g., Small Sediment Diversions, MR-01; Channel Armor Gap Crevasse, MR-06) will serve for comparison and aid in evaluating the effectiveness of MR-09.

Monitoring Elements

The following monitoring elements will provide the information necessary to evaluate the specific goals listed above:

1. Aerial Photography — To evaluate land to water ratios in the individual receiving bays, near vertical, color infrared aerial photography (1:24,000 scale, with ground controls) will be obtained in 1999 (preconstruction) and in 2002, 2007, 2012, and 2017 postconstruction. The photography will be georectified by National Wetlands Research Center (NWRC) personnel using standard operating procedures described in Steyer et al. (1995). Detailed photo-interpretation, mapping, and GIS interpretations are not currently planned on the MR-09 aerial photography.

2. Elevation — To document changes in mean elevation within the receiving bays related to the creation of subaerial land, elevational transect lines will be established across the receiving bays at 12 sites (see figures 3 and 4). The sites chosen will consist of 3 narrow (<100' across) crevasses at an angle of 90° from the main channel (crevasses 12, 9, 51), 3 wide (>150' across) crevasses at an angle of 90° (crevasses 6, 15, 54), 4 narrow crevasses at an angle of 60° (crevasses 45, 27, 20, 11), and 2 wide crevasses at an angle of 60° (crevasses 36, 31). Benchmarks will be installed at the time of construction at the Mississippi River levee and tied to the North American Vertical Datum (NAVD) using an established benchmark located at the USFWS Wildlife Headquarters lookout tower, north of Cubits Gap. Five elevational transect lines and one baseline, which includes at least two benchmarks, will be established perpendicular to the crevasse channel, and distributed evenly across the receiving bay. Elevations will be recorded at 500-ft intervals along each transect and at any significant change in elevation within those intervals. Elevational surveys will also include three cross-sectional profiles of the crevasse-splay channel, with data recorded every 10 ft (3 m) across the channel. Elevation surveys will be conducted as-built and during years 2002, 2007, 2012, and 2017 postconstruction. Monitoring funds are not available to support elevation surveys. As a result, all surveys will be funded through construction funds.

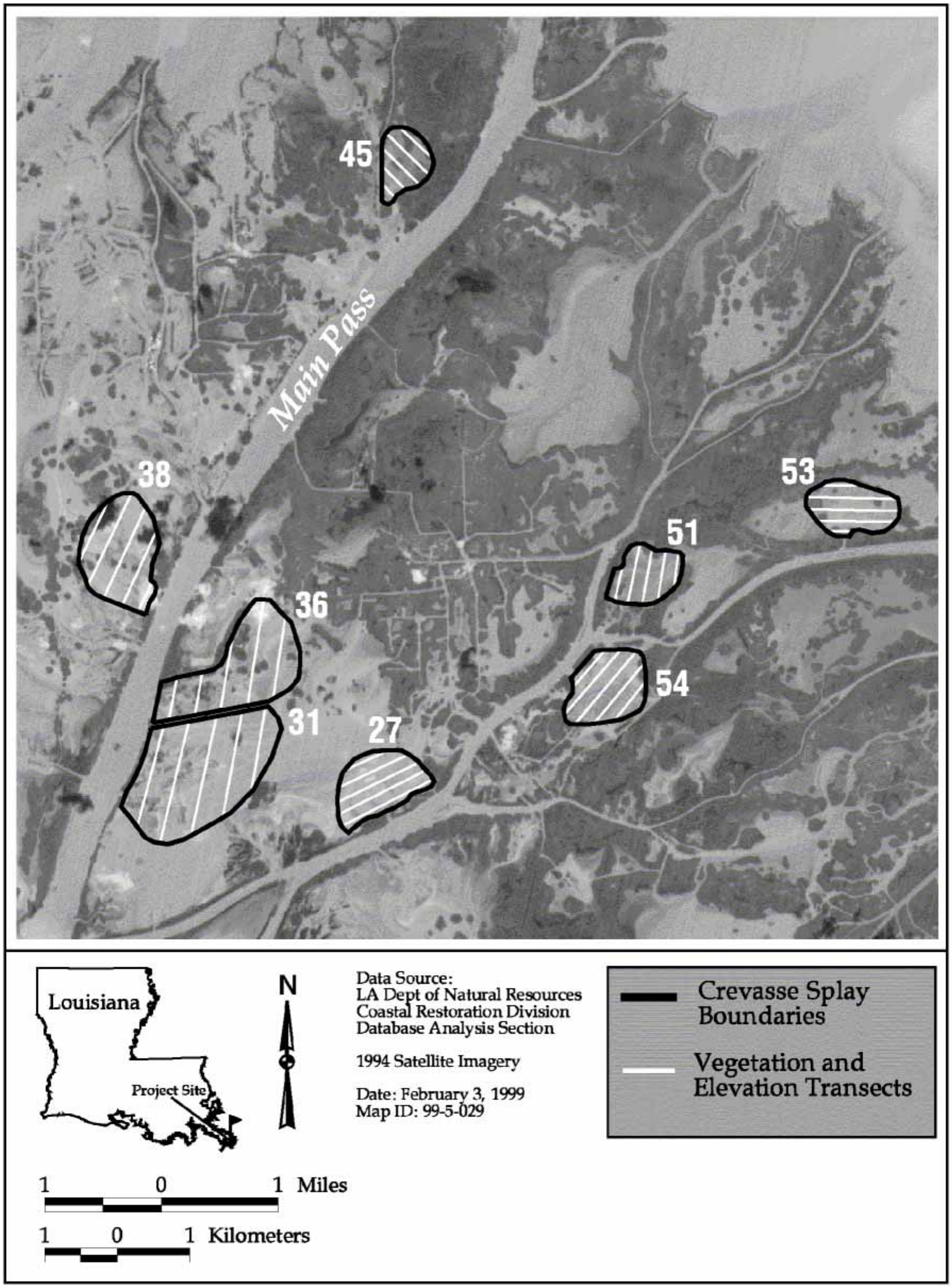

Figure 3. Transects and crevasse splay boundaries for northern part of project area.

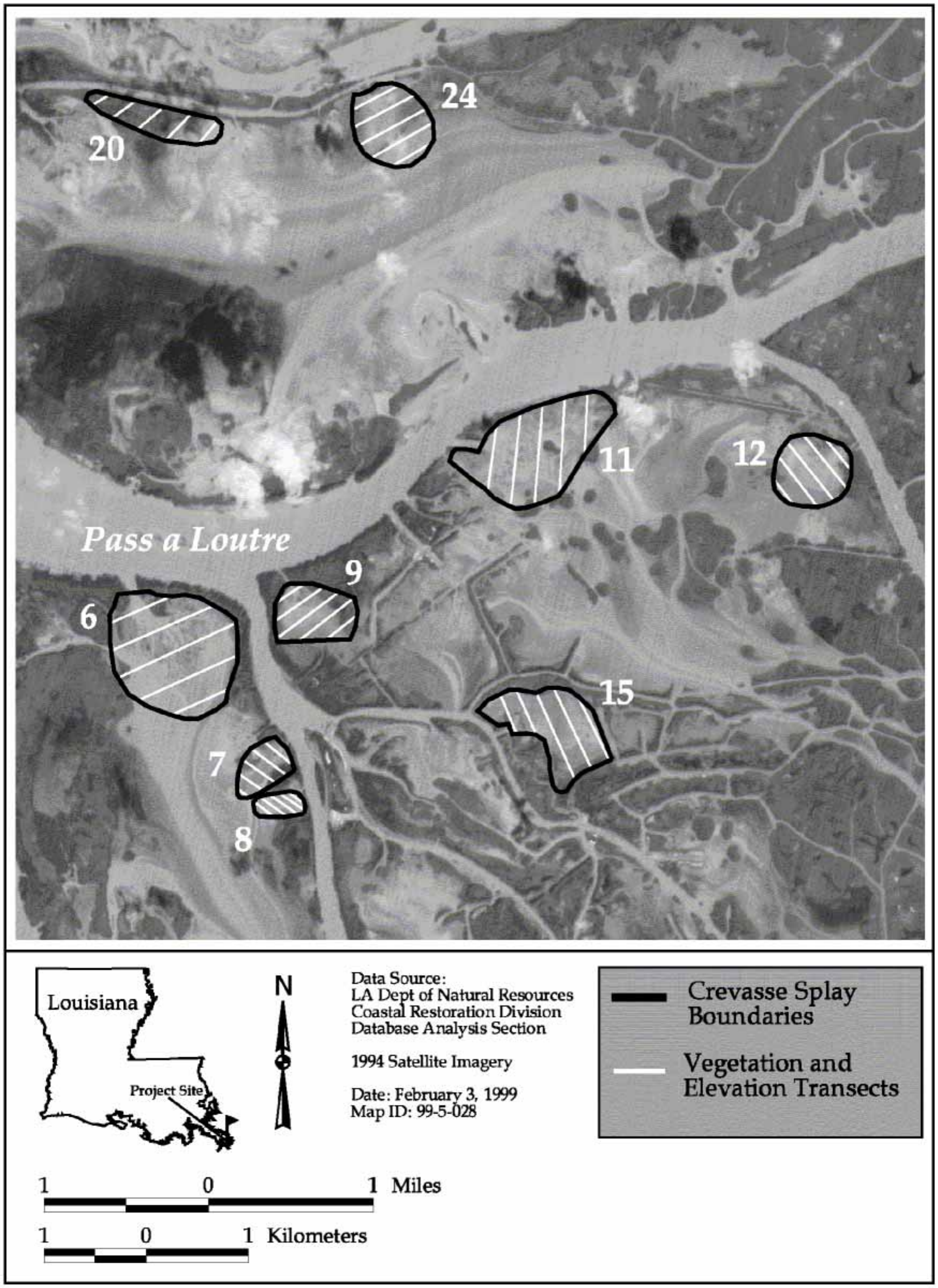

Figure 4. Transects and crevasse splay boundaries for southern part of project area.

3. Vegetation — Plant species composition, percent cover, and relative abundance will be evaluated to document vegetation succession on the 17 receiving bays and to ground-truth aerial photograph interpretations. Vegetation surveys will follow the Braun-Blanquet method as described in Steyer et al. (1995). Transects will be established once the splay islands become subaerial, and will match the transects laid out for the elevation surveys for those respective sites (see figures 3 and 4). Sample stations (duplicate 4 m^2 [2m x2m] plots) along each transect will be established to represent the major plant communities of interest, with at least five stations in each community. Additional transects and sample stations may be established over time as new land is created. Vegetation samples will be conducted in the late summer (mid-July to August) in 1999 (as-built) and in the postconstruction years designated for aerial photography, years 2002, 2007, 2012, and 2017.

Anticipated Statistical Analyses and Hypotheses

The following hypotheses correspond with the monitoring elements and will be used to evaluate the accomplishment of the project goals.

1. Descriptive and summary statistics from color-infrared aerial photography collected pre- and postconstruction will be used to evaluate land to open water ratios and changes in the rate of land loss/gain in the receiving bay. With available historic information available in digitized format from years 1956, 1978, 1988, and 1993 to use in comparison, time-series analyses will be conducted to test for changes in slope between pre- and postconstruction conditions.

   Goal: Maintain or increase land to open water ratio within the receiving bays.

2. Elevational data will be evaluated through paired t-tests or analyses of variance (ANOVA's). These tests will allow for the analysis and documentation of elevational changes in the receiving bays area over time.

   Goal: Increase mean elevation of the receiving bays.

   Hypothesis:

   H_0: Mean elevation in receiving bays area at time i will not be significantly greater than mean elevation at time i-1.

   H_a: Mean elevation in receiving bays area at time i will be significantly greater than mean elevation at time i-1.

3. Vegetation data will be evaluated through paired t-tests or ANOVA's. These tests will allow for the analysis and documentation of vegetation changes within the receiving bays area over

time.

Goal: Increase the mean percent cover of emergent fresh and intermediate marsh type vegetation in the receiving bays.

Hypothesis:

H_0: Emergent fresh and intermediate marsh type vegetative cover in receiving bay at time i will not be significantly greater than vegetative cover at time i-1.

H_a: Emergent fresh and intermediate marsh type vegetative cover in receiving bay at time i will be significantly greater than vegetative cover at time i-1.

Notes

1. Implementation: Start Initial Construction: May 1999

2. NMFS Point of Contact: John Foret (318) 482-5915

3. DNR Project Manager: Ken Bahlinger (225) 342-7362
DNR Monitoring Manager: Jim Bolden (225) 342-0243
DNR DAS Assistant: Brian Zielinski (225) 342-4123

4. The twenty year monitoring plan development and implementation budget for this project is $288,052.00. A monitoring progress report will be available in 2000, and comprehensive reports will be available in 2003, 2008, 2013, and 2018. These reports will describe the status and effectiveness of the project.

5. Near-vertical color-infrared aerial photographs of the project area (or portions of) were taken on the following dates: 11/83, 12/85, 12/90 (1:62,500 scale); and 11/93, 1/96, and 2/99 (1:12,000 scale).

6. Locations of transect sampling may change pending pre- and first post-construction elevational surveys tracking splay formation.

7. Ancillary data on submerged aquatic vegetation (species composition and abundance lists) will be provided at each vegetation sampling time.

8. It is recognized that the present monitoring budget may be insufficient to cover all present and future monitoring goals, especially as the project is expanded in the future. With the addition of crevasse-splays to the project area, there will exist the need to obtain baseline data for any such crevasse-splays. At that time, DNR will contact the lead federal agency (NMFS) to allocate new funding, if available, for the expansion and/or continuation of monitoring goals.

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